PHYTOREMEDIATION GREEN TECHNOLOGY APPLICATION ON SALT-AFFECTED SOILS HEALTH IN HISAR, HARYANA

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Received: September 06, 2018 Accepted: October 25, 2018

ABSTRACT *Saline soil problem in Haryana about one-third area suffer for these problem by the chlorides and sulphates of sodium, calcium and magnesium are the dominating soluble salts the existing technologies on farm salinity management that work well includes surface and sub-surface drainage. These are basically civil engineering technologies and are costly to install, difficult to maintain and have the problem of saline effluent management. Apart from that, under Indian conditions with fragmented land holdings a wide application of such technology, various halophytic taxa especially occurring in saline wastelands could be tailored depending upon the magnitude of salinity or site variations or economical utility of the plants and for additional saline soil reclamation. This bioremediation technology involves the repeated cropping (harvestings] of these hyper accumulators (as has been done in the present investigations as well) until the soils have reached acceptable levels for the farmers to cultivate their regular crops.*

Keywords: *salinity, phytoremediation Green Technology, halophytic taxa*

INTRODUCTION

The problems of soil salinity are most widespread in the arid and semi-arid. Soil salinity is also a serious problem in areas where groundwater of high salt content is used for irrigation. The most serious salinity problems are being faced in the irrigated arid and semi-arid regions of the world and it is in these very regions that irrigation is essential to increase agricultural production to satisfy food requirements. However, irrigation is often costly, technically complex and requires skilled management. Failure to apply efficient principles of water management may result in wastage of water through seepage; over-watering and inadequate drainage result in water logging and salinity problems which reduce the soil productivity, eventually leading to loss of cultivable land. Contaminated soils and waters pose a major environmental problem which may be partially solved by the emerging phytoremediation technology. This cost-effective plant-based approach to remediation takes advantage of the remarkable ability of plants to concentrate elements and compounds from the environment and to metabolize various molecules in their tissues. In recent years, knowledge of the physiological and molecular mechanisms of phytoremediation began to emerge together with biological and engineering strategies designed to optimize and improve phytoremediation.

STUDY AREA

Hisar, the west central most district of Haryana State with a total geographical area of 3983.00 sq. km is lies between the North latitudes 28°56'00": 29°38'30" and East longitudes 75° 21'12": 76°18'12". The district is under control of Hisar division and administratively divided into nine community development blocks namely Agroha, Adampur, Barwala, Bass (Hansi-II), Hansi-I, Hisar-I, Hisar-II, Narnaund, and Uklana Mandi. The district has 05 towns namely Hisar, Hansi, Narnaund, Barwala and Uklana and 269 villages.

The district area falls in Yamuna sub-basin of Ganga basin. There is no natural drainage in the district area. However, the area is drained by network of canals and the artificial drains (field drains/channels). These artificial drains are mainly confined in Bass, Hansi-I, Narnaund and Barwala blocks. There are a total of 39 drains existing in the area, which run for a distance of 126.25. Water logging (water level < 2 m bgl) and prone to water logging (water level between 2 and 3 mbgl) conditions exists in the district covering part of Bass (Hansi-II), Hansi-I and Barwala blocks. The water logged area accounts for 37.65 sq km (0.93 %) of the total district area during Pre-monsoon and 264.55 sq km (6.55 %) during post-monsoon period. However, the area under water logging conditions increases almost 7 fold in post monsoon period.

Eco physiology of native flora of saline wastelands throws light on their further suitable characterization for phytoremediation of soil salinity

Extensive surveys of fallow saline wild lands area west of sector 14 and behind CIRB, Hisar and other saline areas in adjoining area Bass, Hansi 1,Hansi 2,Ulkana,were made and collected, identified and inventories as Thirty Two plant species. The analyses of both plant growth and their rhizospheric soil clearly indicated that *Suaeda fruticosa,* Aerva tomentosa, *Prosopis longlfolia, Salsola baruosma, Portulaea , oleracea, Trianthema* *portulacastrum, Suaeda nudiflora, Calotropis pracera, Atriplex nummularia, Atriplex lentiformis, Atriplex amnicola, Acacia colei, Arundo donax, Solanum xanihocarpum, Heliotropium ramossimum, Acacia ampliceps, Acacia nilotica, Salvadoran persica, Setaria glauca* and *Saccharum munja* were potential salt hyperaccumulator plants belonging to families Portulacaceae, Aizoaceae Compositae Salvadoraceae Asclepiadaceae, Solanaceae, Amaranthaceae, Chenopodiaceae and Poaceae .

The problem of water logging and soil salinity can be effectively countered by a drainage system which in effect means removal of excess of water, and the salts dissolved in it, from the crop root zone. Three kinds of drainage designated as surface drainage, vertical drainage and horizontal sub-surface drainage have been adopted (Garg and Gupta 1997). Surface drainage refers to the technique of removing excess water from the soil surface in time to prevent damage to crops and to keep water from pounding on the surface (ASAE 1979). The term surface drainage applies to situations where overland flow is the major component of the excess and involves water movement to major drains or natural streams. The technique normally involves the excavation of open trenches/drains. Under monsoon Climate, surface water logging is common and, hence, surface drainage has a considerable relevance in India.

IDENTIFICATION AND CHARACTERIZATION OF FLORAS NATIVE TO SALINE SOILS

The word halophyte means 'salt plant' as such but this term is used for plants that can grow in the presence of high concentration of salts particularly chlorides and sulphates of sodium (Garg and Gupta 1997). Jennings (1976) adopted the ecological definition and defined halophytes as 'the native flora of saline soils'.

Zahran (1982) surveyed halophytic vegetation of Egypt and concluded that 90% of these plants are not only highly tolerant to saline soils but also to arid climate. Most (61%) of the succulent halophytes *(Halocnemum strobilaceum, Arthrocnemum glaucum, Salicornia fruticosa, Suaeda fruticosa, S. vermiculata and Zygophyllum album),* 46% of the excretive halophytes *(Limonium pruinosum, Aelurops spp., Sporobolus spicatus, Nitraria retusa, Tamarix mannifera* and *Cressa cretica*) and 45% of the cumulatives *(Typha domengenesie, Pharaqmites auetralis, Juncas rigidus*, *Imperata cylindrical, Scirpus litoralis, Cyperus laeuiqatus* and *Alhagt maurorum*) are widely distributed and dominated in the inland salt marshes and in both the Red Sea and Mediterranean littoral salt marshes of Egypt.

In recent years considerable research efforts have been made in the use of plants to remove inorganic and organic contaminants from the soil by the technique of phytoremediation Chaney *et al. 1997,* Salt et al., 1998). Phytoremediation is visualized as a benign and cost effective plant based technology that depends upon the remarkable ability of some plants to remove or tralize various chemicals (organics and metal ions) from the soil, water and air (Chaney *et al.* 1997). Phytoremediation can be used to bioremediate contaminated soil, water and air. It is very cost effective, non invasive and publicly acceptable way to redress the removal of environmental contaminants.

Where drainage effluent is reused for irrigation, salts are redistributed in the land and if it is disposed into the river systems, they get polluted. Where ground water is of poor quality, the problem of water logging becomes more complex as this water cannot be used for irrigation. In view of the aforementioned problems 'green' and benign technologies. I.e. phytoremediation for salinity control (Robinson et *al.* 1980, Yurtseven and Baran 2000) and biodrainage for both salinity and water table control. (Bell 1999, Ram and Garg 2002, Angrish *et al.* 2006, Ram *et al.* 2006) are emerging as alternative means. These are expected to complement or even replace the conventional drainage/salinity management techniques. Relevant aspects of phytoremediation based salinity remediation are discussed el on Indian desert halophytes like, *Haloxylon recurvum,* H. *salicornicum, Portulaca oleracea; Salsola baryosma, Sesuuium sesuuioides, Suaeda fruticosa, Trianthema triquetra, Zygophyllum simplex,* etc. leading to thickening in leaves, elongation of cells, higher elasticity of cell walls and smaller relative surface area, decrease in extensive growth, and high water content per unit of surface area. Leaves in some succulent halophytes like those in S. *fruticosa,* S. *baryosma* and *T. triquetra* are reduced in surface area, when exposed to a high salt content in the soil. The third type of plant is known as the, cumulative halophyte which lacks any regulatory mechanism. The salt concentration therefore rises during the growing season and, when a certain level is reached, the plant dies. In the Indian arid zone the main cumulative halophytes are: *Faqonia cretica Vernonia cinerea, Eclipta prostrata, Scirpus spp., Cupenis* indicator parameter like ash content and TDS of stem and leaves in general, increased

RESULT

The present study **"Efficacy of some salt hyper accumulatmg plants for salinity phytoremediation"** is a preliminary attempt in this direction. For this sets of experiments were conducted. In the first experiment native flora of five saline locations of Hisar ,Haryana was characterized for their salt hyper accumulation characteristics *vis-a-vis* rhizosphere soil salinity.

1. In the first Eco physiological characterization experiment a total of 44 plant species belonging to sixteen families of Angiosperms were collected from saline wastelands of five locations in Haryana and Rajasthan adjacent area Majority (10) of these plants belonged to the family Chenopodiaceae, followed, by Mimosaceae (4), Poaceae (4), Solanaceae (2), Amaranthaceae (2), and one each to Portulacaceae and Asclepiadaceae.
2. The ECe of the rhizospheric soils of the different locations varied from 5.19 to 60.80. Higher soil Cl^- as compared to, SO_4^{2-} indicated the presence of Cl dominating salinity in all the five locations. pH data of various locations indicated that the soil varied, from neutral to slightly alkaline in nature.
3. The maximum fresh biomass per unit area was accumulated in plant species like *Salsola baryosma, Suaeda fruticosa, Suaeda nudijlora* and *Saccharum munja.* On the basis of their shoot, particularly leaf, mineral Ion [Na^+, K^+, Ca^{2+}, Mg^{2+}, CI^-, SO_4^{2-}) composition characteristics twenty species i.e. *Achyranthes aspera, Aerva tomentosa, Aeluropus lagopoides, Arundo donax, Atriplex amnicola, Atriplex lentiformis, Atriplex nummularia Calotropis, procera, Chenopodium album, Chenopodium ambrosoides, Chenopodium murale, Heliotropium ramosstmum, Parkinsonia aculeata, Portulaca oleracea, Salsola baryosma, Setaria glauca, Suaeda fruticosa, Suaeda nudijlora, Trianthema portulacastrum* and *Xanthium strumarium* were found promising.
4. Salt hyperaccurnulation with increasing level of salinity in all the experimental plants. The ash content of stem and leaves was found maximum in species like *Achyranthes aspera, Atriplex amnicola, Atriplex lentiformis, Heliotropium ramoesunum, Portulaca oleracea, Salsola baryosma, Suaeda fruticosa* and *Trianthema portulacastrum* and least in *Chenopodium* species and *Arundo donax.* Again the TDS of stem and leaves was highest in Sua*eda nudiflora, Suaeda fruticosa, Atriplex amnicola, Atriplex lentiformis* and *Trianihema portulacasirum.*
5. Total phyto accumulation of different ions per pot [Na^+, K^+ Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}) in the above ground biorriass was also enhanced with increasing level of salinity from 0 to 16 dSm^{-1}. It was found maximum in species like *Atriplex amnicola, Suaeda nudiflora* and *Salsola baryosma* followed by *Suaeda fruticosa, Trianthema portulacastrum, Atriplex leniiformis, Arundo donax* and *Aerva tomentosa.* Whereas the least was found in case of *Chenopodium ambrosoides, Aeluropus lagopoides* and *Setaria glauca.*
6. It was observed that the pH, ECe, SAR and different soil ionic contents like Na^+, K^+ Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-} and total amount of ions declined in the soil after plantation and harvesting of different plant species. The maximum depletion in the mean ionic content and ECe in the soil was observed by the plant species like *Suaeda* species, *Atriplex* species and *Salsola baruosma.*
7. It was estimated that the best salt hyperaccumulator plants were *Suaeda nudiflora, Portulaca oleracea, Suaeda fruticosa, Atriplex amnicola, Salsola baryosma* and *Atriplex leniiformis* on the basis of phytoaccumulation of salt ions in their biomass at 16 dSm^{-1}. Our estimates further showed that at 16 dSm^{-1} of salinity *Suaeda nudiflora, Portulaca oleracea, Suaeda fruticosa, Salsola banjosma, Haloxylon recurvu*m, *Atriplex lentiformis* and *Atriplex amnicola* could phytoaccumulate 101.3, 89.4, 74.7, 66.7, 62.1, 60.6 and 56.7 kg ha^{-1} $year^{-1}$ of toxic salt ions in their above ground biomass, respectively. These findings are in concomitant with decrease in soil ECe at the rate of 2.31 to 2.86 dSm^{-1} per year. It is opined that these salt hyper accumulator plants are fit for further pilot and field level phytoremediation studies.

CONCLUDING REMARKS AND FUTURE PROJECTIONS

On the basis of the present investigation, it is inferred conclusively beyond doubt that Chenopods particularly like *Suaeda nudiflora, Suaeda fruticosa* all the three *Atriplex* spp., *Haloxylon recurvum, Salsola baryosma* and to some extent *Portulaca oleracea* (Portulacaceae) were able to phytoremediation the saline soils very efficiently and effectively. These could provide proficient, sustainable and low cost plant based technology for greening of saline waste lands, amelioration of physical and chemical nature of top layer of soil especially in arid and semi-arid tracts of India. These plants also provide fodder, substituted vegetables, grain, fire (fuel) wood and oil and hence are economically viable plants as well for livestock and rural people. These also stabilize consistently ever eroding saline lands. Feasibility in the near future is the production of bio-salt from these hyper accumulator plants.

In fact these plants use sun's energy to remove salt ions from soil. So transpiration/translocation mediated and active uptake of salt ions is the core of phytoremediation technology. Secondly, the various halophytic taxa especially occurring in saline wastelands could be tailored depending upon the magnitude of salinity or site variations or economical utility of the plants and for additional saline soil reclamation. This bioremediation technology involves the repeated cropping (harvestings] of these hyper accumulators (as has been done in the present investigations as well) until the soils have reached acceptable levels for the farmers to cultivate their regular crops since root stocks of these plants regenerate vegetative after harvesting of above ground plant parts. Even various saline parks could be raised where co-cultivation of these salt hyper accumulators along with other commercial crops could be undertaken for soil salinity amelioration on an ongoing basis. Even wheat, *Brassica, Sesbania* and other grasses which have been more economically viable as well can also be grown side by side with these hyper accumulator plants for complementary use in various crop systems. Furthermore, these hyper accumulator plants could be harvested and dumped as manageable efficient salt concentrations at point sink, or incinerated for further mineral industrial uses as well. Another most effective utilization of these harvestings from these hyper accumulator plants could be towards bio-salt production, which shall facilitate natural cycling of the salt.

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